Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 20s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Role Of Artificial Intelligence in Forensic Odontology: A Review

Dr. Sourabh Khandelwal[*1], Dr. Rajeev Srivastava[2], Dr. Mahendra Dave[3], Dr. Ankush Jain[4], Dr. Kruti Bais[5], Dr. Sarthak Shrivastav[6]

[1*]Senior Lecturer,Department of Prosthodontics and Crown & Bridge, Index Institute of Dental Sciences, Malwanchal University, Indore, Madhya Pradesh, India

[2]Professor and Head,Department of Prosthodontics and Crown & Bridge, Index, Institute of Dental Sciences, Malwanchal University, Indore, Madhya Pradesh, India

[3]Reader, Department of Prosthodontics and Crown & Bridge, Index Institute of Dental Sciences, Malwanchal University, Indore, Madhya Pradesh, India

[4]Reader, Department of Prosthodontics and Crown & Bridge, Index Institute of Dental, Sciences, Malwanchal University, Indore, Madhya Pradesh, India

[5]Reader, Department of Prosthodontics and Crown & Bridge, Index Institute of Dental Sciences, Malwanchal University, Indore, Madhya Pradesh, India

[6]Senior Lecturer,Department of Prosthodontics and Crown & Bridge, Index Institute of Dental Sciences, Malwanchal University, Indore, Madhya Pradesh, India

***Corresponding Author:**

Dr. Sourabh Khandelwal

Senior Lecturer, Department of Prosthodontics and Crown & Bridge, Index Institute of Dental Sciences, Malwanchal University, Indore

Cite this paper as: Dr. Sourabh Khandelwal, Dr. Rajeev Srivastava, Dr. Mahendra Dave, Dr. Ankush Jain, Dr. Kruti Bais, Dr. Sarthak Shrivastav, (2025) Role Of Artificial Intelligence in Forensic Odontology: A Review. *Journal of Neonatal Surgery*, 14 (20s), 250-254.

Received: 29/02/2025 **Accepted:** 27/03/2025 **Published:** 10/04/2025

ABSTRACT

Forensic odontology is a specialized branch of dentistry dealing with the identification of individuals through dental evidence for investigation or legal proceedings. Traditionally, maintaining and matching dental records and radiographs, bite mark analysis, age estimation, and gender estimation were done manually, which was time-consuming and prone to errors. However, the introduction of artificial intelligence (AI) is a game changer in this field, addressing the challenges faced by manual methods. It has opened the possibilities of more precise, accurate, reliable, and efficient identification and reduced subjectivity. However, challenges regarding ethical aspects, data privacy and the need for standardization have to be addressed. This review emphasizes the significant role of AI in enhancing forensic odontology and its potential to transform this field..

Keywords: *artificial intelligence, dental identification, forensic odontology*

1. INTRODUCTION

Forensic odontology, a field that combines dentistry and legal investigations, is crucial for identifying individuals. Teeth, the hardest human tissue, are resistant to severe environmental conditions such as high temperature, pressure and decomposition. It is especially used when visual identification is not possible and there are no traces of soft tissue. In addition, in natural and mass disasters such as earthquakes, tsunamis, landslides, bomb explosions, etc., where bodies are severely damaged and disfigured, forensic odontology can provide reliable results.[1]

Forensic dentistry uses various methods for identification, such as dental record maintenance, imaging techniques, bite-mark analysis, DNA analysis, lip print analysis (cheiloscopy), palatine rugae pattern analysis (palatoscopy), and age and gender determination. Current concepts include facial reconstruction, denture identification, comparison microscopes, tongue prints, vitropsy, and related software in forensic dentistry.[2] Artificial intelligence (AI), a result of the technology revolution, has the potential to revolutionize this field by reducing the time, labour, human error and enhancing the precision and efficiency of

the identification process.

The term artificial intelligence (AI) refers to a broad range of methods that allow computers to simulate human behaviour and outperform humans in making decisions in order to do challenging tasks with little or no assistance from humans.[3] It is dominating our lives in the form of ChatGPT, Google Assistant, etc. AI models trained for decision-making, problem-solving, and dental and medical diagnostics offer reliable information and reasoning for clinical decision-making, making them a breakthrough in providing reliable information in decision-making.[4] Machine learning algorithms can recognize intricate dental patterns, compare dental records with post-mortem findings, and identify potential matches or discrepancies. AI can also create 3D dental models for detailed comparisons between ante-mortem and post-mortem dental records.[5] This review is an attempt to highlight the role of AI in advancing forensic odontology.

APPLICATIONS OF AI IN FORENSIC ODONTOLOGY:

Bite mark analysis:

Bite mark analysis is a forensic science that looks at and compares bite marks left by people on food, skin, or other items.[6] It is based on the principle that "no two mouths are alike,"[7] and enough information about the uniqueness is provided during the bite process to make identification easier.[8] Bite mark analysis involves preserving, examining, documenting, comparing to known dental records, and interpreting the results.[9] This is the essential evidence in cases of child abuse, rape, sexual assault, and homicide. The field of forensic odontology is under scrutiny due to concerns about the accuracy of bite marks as evidence in court. This skepticism stems from a weak scientific foundation, high error rates, and the unsatisfactory nature of skin as a substrate for tooth impression registration. In addition, factors such as skin elasticity, unevenness, swelling, and healing may restrict the scientific validity of bite mark comparisons, challenging the abilities of the forensic dentists.[1]

Integration of AI helps by enhancing bite mark images and identifying patterns. It can also match postmortem bite marks to the dental records for evidence in criminal cases. Automation can improve the identification process. A preliminary study by Mahasantipiya et al.[10] on bite mark identification using artificial neural networks (ANN) developed a high-performance, accurate machine learning model to overcome human bias. Bite mark samples are collected in five different biting positions. The digital camera was used to capture bite marks from samples. After choosing a few particular bite mark characteristics to train the model, the trained networks produced an impressive matching accuracy. The study stated that despite its reasonable accuracy, it has high potential and requires further improvement.

A semi-automated examination of human bite marks using two distinct computer software packages was proposed by Molina et al.[11] DentalPrint© used 3D dental cast photos to create biting edges, and BitePrint© was used for characterizing the biting edges. The ROC curve was used to assess performance. The Euclidean distance of lower tooth rotation had the highest area under the ROC curve (AUC) of 0.73. As a result, their suggested technique for measuring lower tooth rotation might be useful in identifying the people who left bitemarks.

Age estimation:

Estimating a person's age is one of the objectives of forensic investigation in order to create their biological profile, which is crucial in criminal examinations and scenarios of disasters. Commonly, dental age estimation is done by assessing the stage of tooth development and mineralization and using hand-wrist radiographs. Artificial intelligence has led to the development of programming neural networks for automatically determining age, with the selection process influenced by available materials, time, facilities, and expert experience. Nowadays, automated tooth allocation and digital dental panorama image data are used.

Tobel et al.'s[12] study used an AI-based model to stage lower third molar development on panoramic radiographs. The deep learning convolutional neural network approach outperformed all tested approaches, demonstrating efficiency and equivalent accuracy when compared to trained examiners. Blanco et al. used Wide ResNet and DenseNet software on dental panoramic images to determine chronologic age. These models used supervised learning techniques and heuristic grouping. These models showed high accuracy, especially in young patients with a ±3-year deviation. Deep convolutional neural networks (DCNN) enable age estimation by segmenting images and measuring teeth. DCNNs also optimize dental X-ray image segmentation, improving analysis efficiency.[13]

Gender determination:

Sex determination aids in criminal investigations, mass catastrophe victim identification, and missing persons cases by identifying victims based on their sexual orientation. Forensic odontologists can assist in this process by analyzing teeth and skull characteristics, as male and female teeth have distinct morphology, crown size, and root length, and skull patterns and characteristics also differ. Patil et al.[14] have proposed a study that uses digital panoramic radiographs and mandibular morphometric data to determine the gender. Discriminant analysis and logistic regression, two common statistical methods for determining gender that produce great results, were compared to artificial neural networks. However, the study's findings confirmed that the AI model outperformed the other two models. Fidya et al.'s[15] study on AI-based technology for identifying sexual dimorphism in canines found that Naive Bayes, decision tree, and multi-layer perceptron methods were highly accurate in determining gender determination of canine teeth. The multilayer perceptron method was found to be the most appropriate, with a higher accuracy rate.

Automated dental record analysis:

Automated dental identification systems are computer-aided software used for postmortem identification of deceased

individuals based on dental characteristics. They consist of a search and retrieval stage based on potential similarities and a verification stage based on dental image comparisons. These systems provide automated search and matching capabilities for digitized radiographs and photographs.[16] Reesu et al.[17] used Automated Identification from Dental Data software (AutoIDD) using 3D dental scans where every reference scan is automatically aligned and superimposed with the test scans. They stated that this software clearly differentiates the matches from non-matches with high accuracy.

Image Processing and Enhancement

AI-powered image processing tools can improve dental image quality, aiding in the extraction of valuable information, such as enhancing the resolution of blurry X-rays, highlighting specific features, and reconstructing missing parts of dental images, especially in damaged or incomplete evidence.

RECENT ADVANCES

Facial reconstruction:

Facial reconstruction is the process that aims to rebuild a victim's facial look from the underlying skull. The reconstruction procedure is guided by dental data, including the size of the jaw, the occlusal relationship, and the location and alignment of the teeth. Reconstructing a person's face can help them be recognized by others and identify missing people. Computerized methods for 3D facial reconstruction have been attempted to be built. These techniques use software to convert laser-scanned 3D faces from skull scans and then image them as a fully shaded 3D surface.[18] AI-driven face restoration technology uses computer vision algorithms to repair missing or damaged facial components, improving image quality and enhancing facial details and textures. Techniques such as denoising, deblurring, super-resolution, and image inpainting eliminate the impact of deteriorating image quality and enhance the identity recognizability of facial appearance.[19] Deep learning, particularly convolutional neural networks (CNNs) and generative adversarial networks (GANs), has become the core method of image restoration, making it particularly effective in restoring obscured or damaged areas.[20] These techniques help improve the accuracy and recognizability of facial appearance. For drawing faces, computer programs such as the Vitrea 2.3 version of volumetric visualization are very helpful.[21]

Vitropsy:

Vitropsy is a non-contact autopsy technique.[2] Virtual autopsy applications in forensic odontology involve collecting dental data and comparing ante- and post-mortem orthopantomograms. This process integrates radiographic imaging, CT scanning, 2D and 3D video, photos, and photogrammetry documentation, allowing remote examination of jaws and teeth without traditional dental autopsy procedures. Virdentopsy is a registered brand that offers a remote forensic odontological evaluation of post-mortem dental data from unidentified human remains through a dedicated website.[22]

Softwares in forensic odontology:

Software like Windows Identification, Disaster and Victim Identification (DAVID), automated dental identification system (ADIS), unified victim identification system/ unified victim identification module (UVIS/ UDIM), Computer assisted postmortem identification (CAPMI), GNU Image Manipulation Program (GIMP) and Image J, Selfie forensic Id application aid in forensic odontology. Adobe Photoshop and Dentascan, scan deceased dentition quickly and provide results within seconds.[23]

ADVANTAGES:

- **Speed and efficiency**: Artificial intelligence aids forensic dentists in efficiently analyzing vast dental data, including imaging and patient records, to swiftly, within seconds, accelerate investigations. In addition, it is capable of concurrently analyzing thousands of documents, something that human experts cannot do in a short duration of time.
- **Accuracy and Reliability:** Various studies exhibited precision and accuracy on par with those of qualified examiners and have the extra benefit of conquering human errors. The problem of subjectivity with analysis is also abolished.
- **Automation**: Certain operations, like dental image processing, can be automated with artificial intelligence to decrease the need for manual labor and improve identification speed and accuracy.
- **Cost effectiveness**: initial implementation may be costly, but over a period of time it saves on long-term expenses.

2. CHALLENGES AND LIMITATIONS:

- **Data privacy and lack of security**: A massive amount of patient data collected is incorporated into this AI system, which raises concern about privacy and security issues.
- **Interpretability and transparency**: AI models are black boxes, often difficult to understand on what basis a decision was made. Hence, the use of this field in the courtroom is quite questionable.
- **Quality of data and bias**: AI models require high-quality data input; poor data quality can demolish the dependability of results—that is, it can lead to inaccurate outcomes.
- **Technical expertise**: AI requires substantial training and knowledge of programming.
- **Employment displacement**: the automation process decreases the employment opportunities. It should be used as

a support tool rather than a replacement.

- **Ethical and legal considerations**: consent to use dental records, algorithmic transparency, and rigorous validation and certification to use AI data as evidence.
- **Lack of standardization and protocols:** no known protocol has yet been developed for utilizing and analysing AI data in forensic dentistry. Lack of standardization and reporting formats which could ensure consistency and reliability.

3. FUTURE IMPLICATIONS:

Future studies should explore the use of AI in real-life incidents. Currently, AI has been used in only few aspect of forensic dentistry however, other aspects like lip prints, palatal rugae, tongue prints, and cemental lines should also be investigated. Further, the digital dental record of an individual has to be created and maintained in a government database to enhance the investigation process and accuracy.

4. CONCLUSION

Technology advancements and digitalization are at rapid phase. Inculcating the AI in forensic dentistry should not lag behind as it can contribute and enhance investigations. Constant update of forensic tool is much needed as it is a booming branch and has promising scope.

REFERENCES

[1] Mohammad N, Ahmad R, Kurniawan A, Mohd Yusof MY. Applications of contemporary artificial intelligence technology in forensic odontology as primary forensic identifier: A scoping review. Front Artif Intell. 2022 Dec 6;5:1049584. doi: 10.3389/frai.2022.1049584

[2] S Renuga, SN Sahana, Yadav ST, Khatoon H, Kulkarni M, Chakraborty A. Current Advances in Forensic Dentistry-A Review Article. Int J Dent Sci Innovative Res. 2021; 4(4):16 – 22.

[3] Janiesch C, Zschech P, Heinrich K. Machine learning and deep learning. Electr markets. 2021 Sep;31(3):685-95. doi: 10.1007/s12525-021-00475-2

[4] Khanagar SB, Vishwanathaiah S, Naik S, Al-Kheraif AA, Divakar DD, Sarode SC, Bhandi S, Patil S. Application and performance of artificial intelligence technology in forensic odontology–A systematic review. Legal Med. 2021 Feb 1;48:101826. doi: 10.1016/j.legalmed.2020.101826

[5] Kirchhoff S, Fischer F, Lindemaier G, Herzog P, Kirchhoff C, Becker C, Bark J, Reiser MF, Eisenmenger W. Is post-mortem CT of the dentition adequate for correct forensic identification?: comparison of dental computed tomograpy and visual dental record. Int J legal Med. 2008 Nov;122:471-9.

[6] Daniel MJ, Pazhani A. Accuracy of bite mark analysis from food substances: A comparative study. J Forensic Dent Sci. 2015;7(3):222 6.

[7] Gorea RK, Jasuja OP, Abuderman AA, Gorea A. Bite marks on skin and clay: A comparative analysis. Egypt J Forensic Sci. 2014 Dec 1;4(4):124-8. doi: 10.1016/j.ejfs.2014.09.002

[8] Maji A, Khaitan T, Sinha R, Sarkar S, Verma P, Shukla AK. A Novel Computer-Assisted Method of Bite Mark Analysis for Gender Determination. J Environ Pub health. 2018;2018(1):7130876.

[9] van der Velden A, Spiessens M, Willems G. Bite mark analysis and comparison using image perception technology. J Forensic Odontostomatol. 2006 Jun;24(1):14–7.

[10] Mahasantipiya PM, Yeesarapat U, Suriyadet T, Sricharoen J, Dumrongwanich A, Thaiupathump T. Bite mark identification using neural networks: A preliminary study. World Congress Eng. 2011; 1: 16-18.

[11] Molina A, Ramos B, Torres JC, Martin-de-las-Heras S, Bravo Perez M. Dental parameter quantification with semi-automatized computational technology for the analysis of human bitemarks. Aust J Forensic Sci. 2022 Mar 4;54(2):247-57. doi:10.1080/00450618.2020.1793385

[12] De Tobel J, Radesh P, Vandermeulen D, Thevissen PW. An automated technique to stage lower third molar development on panoramic radiographs for age estimation: a pilot study. J forensic odonto-stomatol. 2017 Dec 1;35(2):42.

[13] Kurniawan, A, Novianti, A, Lestari FA, Ramaniasari SM. Integrating artificial intelligence and adult dental age

estimation in forensic identification: A literature review. World J Adv Res Reviews. 2024; 21(2), 1374-79

[14] Patil V, Vineetha R, Vatsa S, Shetty DK, Raju A, Naik N, et al. Artificial neural network for gender determination using mandibular morphometric parameters: A comparative retrospective study. Cogent Engineering. 2020;7(1):1723783. doi:10.1080/23311916.2020.1723783

[15] Fidya F, Priyambadha B. Automation of gender determination in human canines using artificial intelligence. Dent J. 2017 Sep 30;50:116-20. doi: 10.20473/j.djmkg.v50.i3.p116-120.

[16] Devi P, Thimmarasa VB, Mehrotra V, Singla V. Automated dental identification system: An aid to forensic odontology. J Indian Acad Oral Med Radiol. 2011 Jul 1;23(Suppl 1):S360-4.

[17] Reesu GV, Woodsend B, Mânica S, Revie GF, Brown NL, Mossey PA. Automated Identification from Dental Data (AutoIDD): A new development in digital forensics. Forensic Sci Int. 2020 Apr 1;309:110218.

[18] Verzé L. History of facial reconstruction. Acta Biomed. 2009 Apr 1;80(1):5-12.

[19] Yang M, Li S, Zeng J. The Effects of AI-Driven Face Restoration on Forensic Face Recognition. Appl Sci. 2024 Apr 29;14(9):3783. doi: 10.3390/app14093783

[20] Zhang Y, Xie H, Zhuang S, Zhan X. Image Processing and Optimization Using Deep Learning-Based Generative Adversarial Networks (GANs). J Artif Intell General sci (JAIGS) ISSN: 3006-4023. 2024 Jun 11;5(1):50-62.

[21] Rocha SD, Ramos DL, Cavalcanti MD. Applicability of 3D-CT facial reconstruction for forensic individual identification. Pesquisa Odontológica Brasileira. 2003;17:24-8.

[22] Nuzzolese E. Virdentopsy: Virtual dental autopsy and remote forensic odontology evaluation. Dent J. 2021 Sep 5;9(9):102. doi:10.3390/dj9090102

[23] Anuja P, Doggalli N. Software in forensic odontology. Indian Journal of Multidisciplinary Dentistry. 2018 Jul 1;8(2):94.

.